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955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B69 10004

SUBJECT: Stage Weights of Nuclear Lunar Shuttle - Case 105-3

DATE: October 2, 1969

FROM: A. L. Schreiber

NASW-417

ABSTRACT

A nuclear stage with a 75,000 lb thrust engine is considered as a lunar shuttle operating between low-parking orbits at the earth and the moon. Gravity losses are shown to have a substantial impact on stage weight for stage mass fractions less than .80.

(NASA-CR-107462) STAGE WEIGHTS OF NUCLEAR LUNAR SHUTTLE (Bellcomm, Inc.) 7 p

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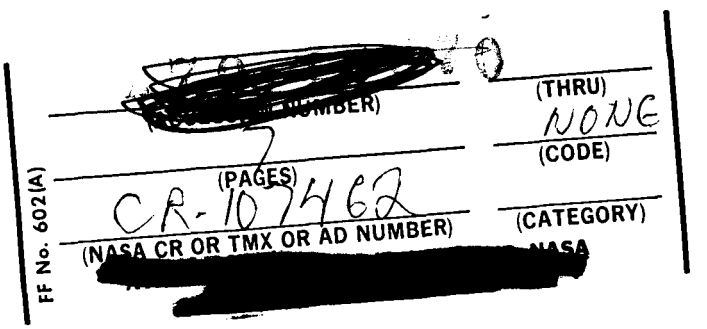

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MEMORANDUM FOR FILE

Stage weights have been computed for a nuclear shuttle operating between low parking orbits at the earth and the moon. Payloads of 100,000 lbs outbound and 16,000 lbs return were used throughout. Specific impulses of 800 and 850 seconds were considered. Two ΔV budgets were used:

	Normal Return	Slow Return
TLI	10,300	10,300
LOI	3,400	3,400
TEI	3,800	2,700
EOI	10,500	10,500

The first of these reflects a more or less nominal Apollo mission with EOI derived from reentry and circular velocities. The second represents a reduced energy return with no LM rescue capability and ignores the small difference in EOI.

Finite burns with a thrust of 75,000 lbs were considered only in the TLI phase of the mission, the other ΔV's being treated as impulses. Gravity losses were obtained by first integrating a gravity turn from a 100 nm circular parking orbit until the instantaneous orbital energy equaled a targeted value of -1.04506×10^7 ft^2/sec^2 (the orbital energy after giving a 10,300 ft/sec impulse from a 100 nm circular orbit). The integration established the mass ratio, r, for TLI and the loss was then computed as

$$\Delta V_{loss} = I_{sp}\, g \log r - 10{,}300$$

Parallel computations were carried out taking all ΔV's as impulses in order to show the impact of TLI gravity loss on total stage weight.

Computations were carried out for stage mass fractions of λ = .80 - .70 where possible. However, the lower values are not realizable with the TLI treated as a finite burn. The approximate lower limits of λ are as follows:

	Normal Return	Slow Return
I_{sp} = 800 sec	.75	.74
I_{sp} = 850 sec	.73	.72

Figures 1-4 present the results graphically. Each one relates to a fixed I_{sp}, 800 or 850 seconds, and a fixed ΔV budget, normal return or slow return. Each one presents, as a function of λ, stage weight with all ΔV's as impulses, stage weight with TLI a finite burn, and gravity losses for the latter. Typical results are as follows for λ = .75:

Normal Return

I_{sp}	Impulsive	Finite Burn	Gravity Loss
800 sec	351,000 lbs	544,900 lbs	2078 ft/sec
850 sec	273,000 lbs	327,800 lbs	1074 ft/sec

Slow Return

800 sec	306,400 lbs	395,600 lbs	1376 ft/sec
850 sec	245,700 lbs	282,400 lbs	885 ft/sec

A. L. Schreiber

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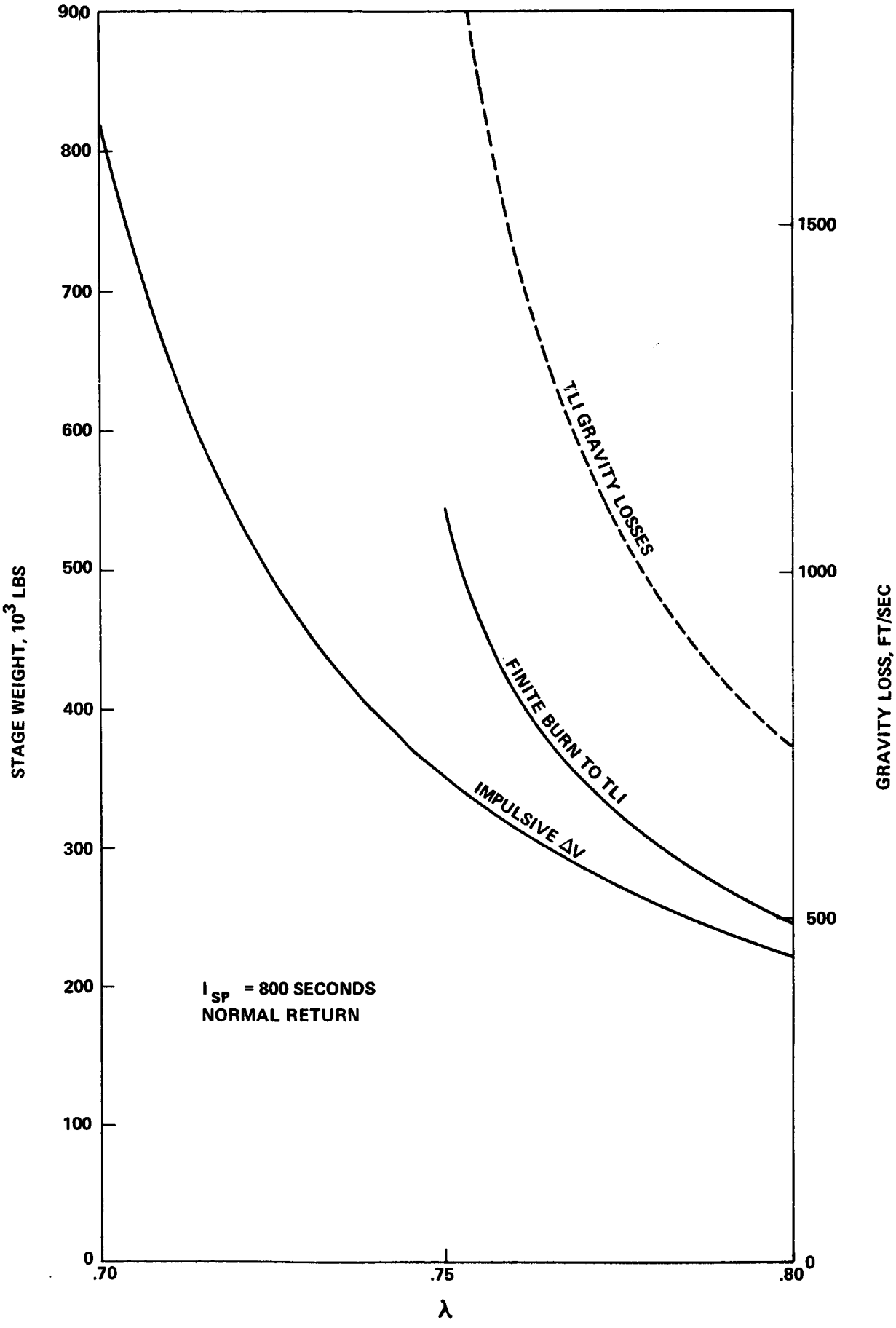
900
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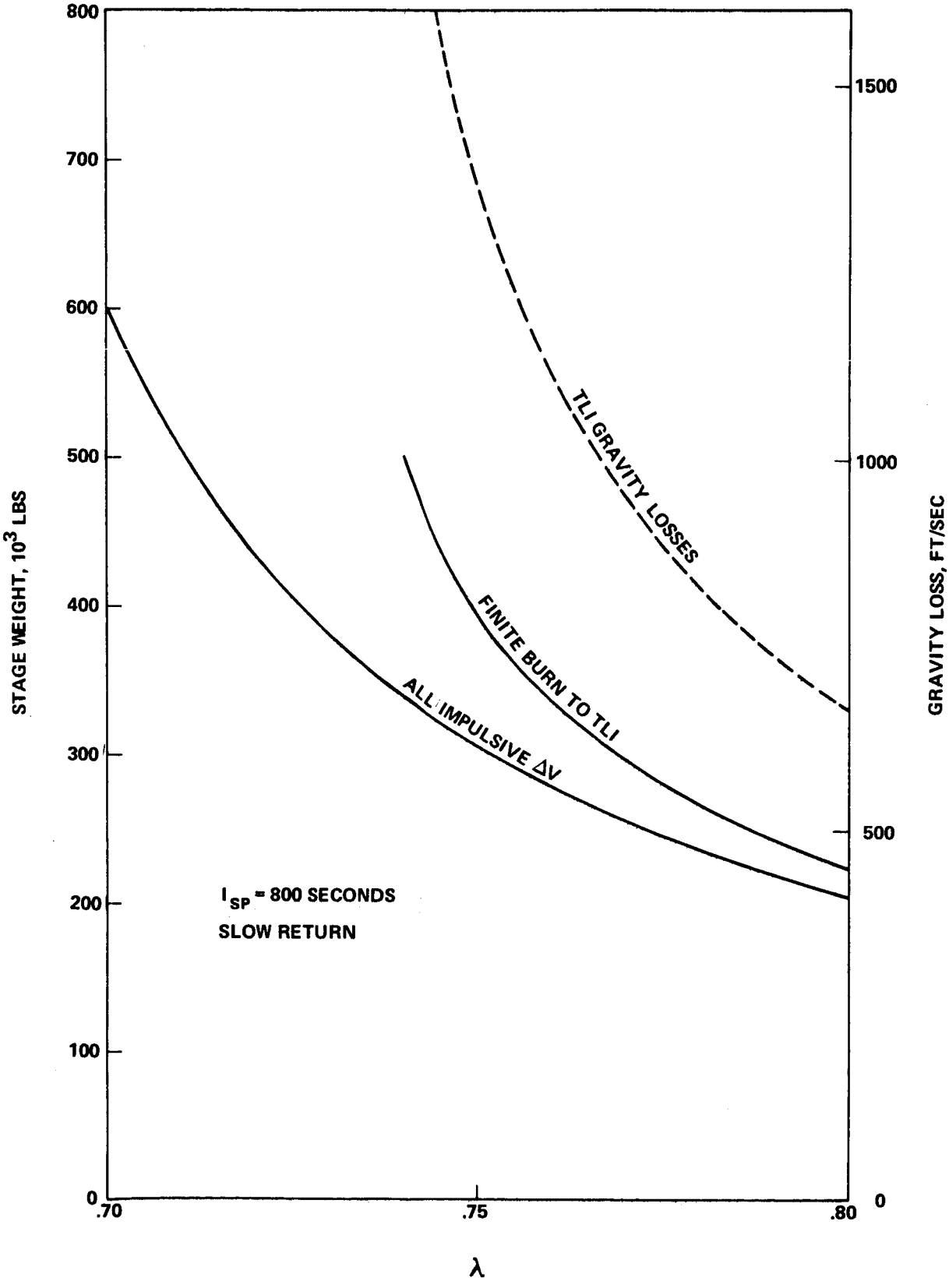
.80
λ
STAGE WEIGHT, 10^3 LBS
GRAVITY LOSS, FT/SEC
T.L.I GRAVITY LOSSES
FINITE BURN TO TLI
IMPULSIVE ΔV
I_{SP} = 800 SECONDS
NORMAL RETURN

FIGURE 1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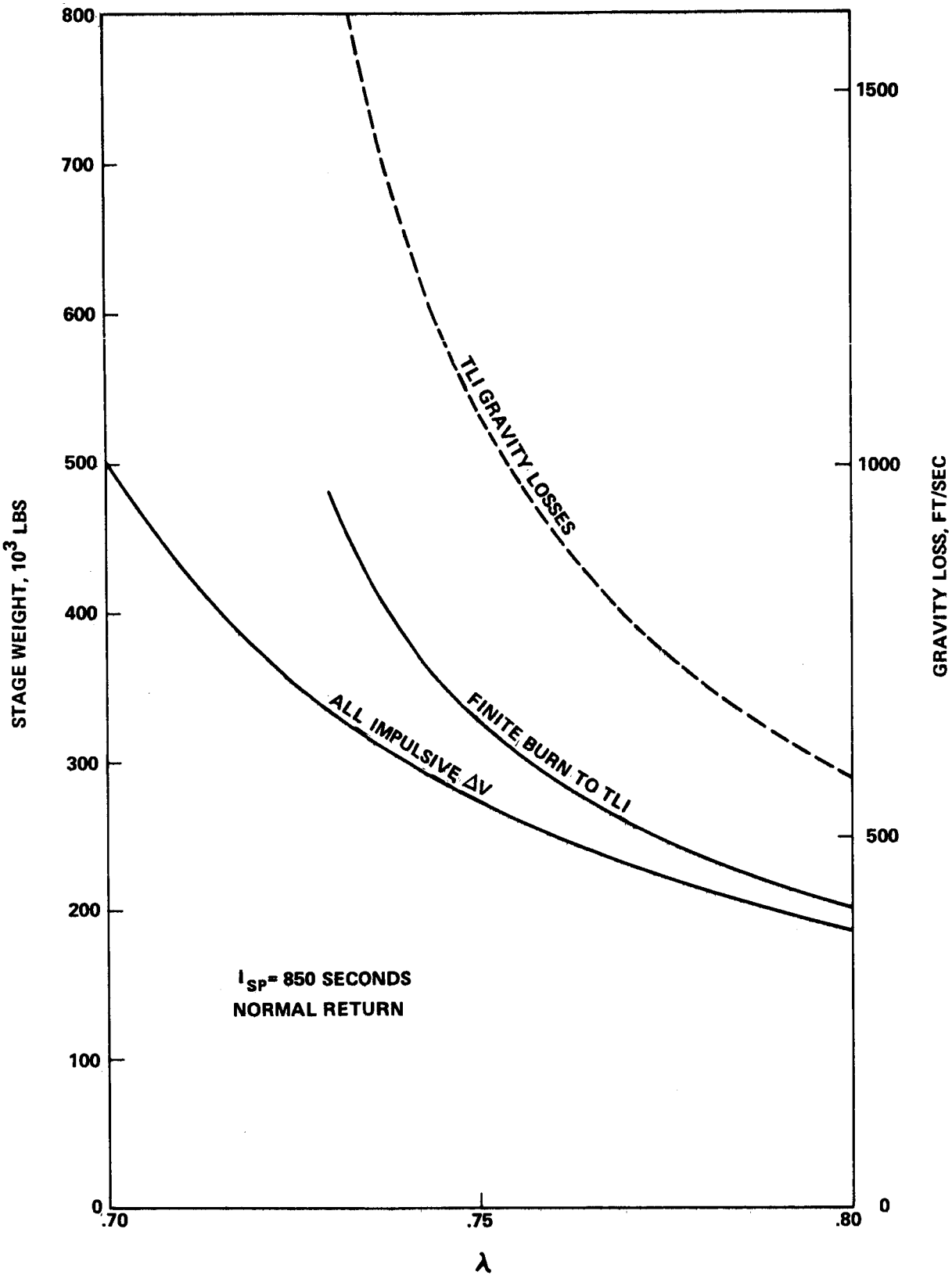
.70
.75
.80
λ
STAGE WEIGHT, 10^3 LBS
GRAVITY LOSS, FT/SEC
TLI GRAVITY LOSSES
FINITE BURN TO TLI
ALL IMPULSIVE ΔV
I_{SP} = 800 SECONDS
SLOW RETURN

FIGURE 2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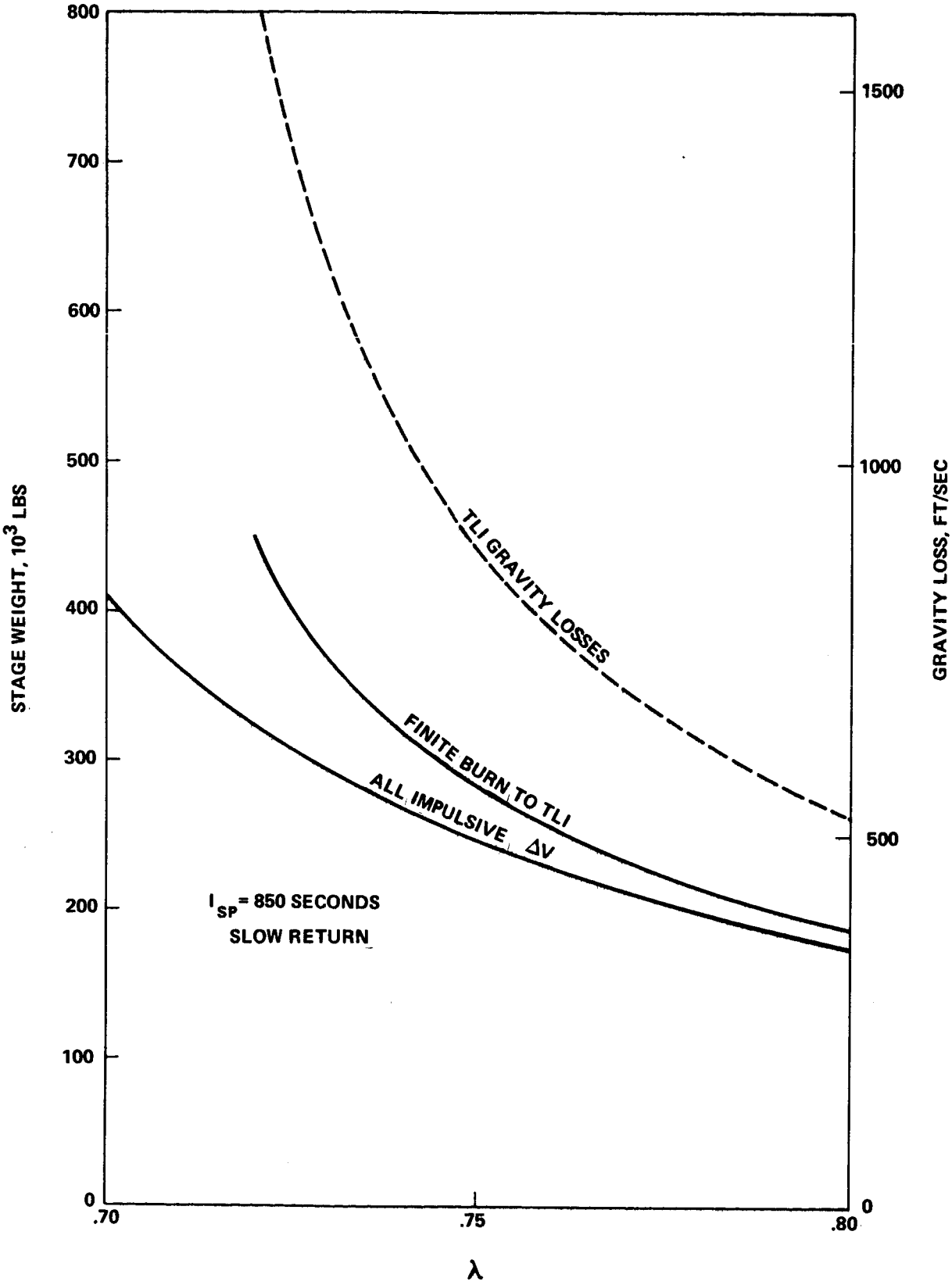
λ
STAGE WEIGHT, 10^3 LBS
GRAVITY LOSS, FT/SEC
TLI GRAVITY LOSSES
FINITE BURN TO TLI
ALL IMPULSIVE ΔV
I_{SP} = 850 SECONDS
NORMAL RETURN

FIGURE 3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.70
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.80
λ
STAGE WEIGHT, 10^3 LBS
GRAVITY LOSS, FT/SEC
TLI GRAVITY LOSSES
FINITE BURN TO TLI
ALL IMPULSIVE ΔV
I_{SP} = 850 SECONDS
SLOW RETURN

FIGURE 4

BELLCOMM, INC.

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By: A. L. Schreiber

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